

I claim:

1 1. A rotary actuator comprising:  
2 an actuator shell;  
3 a planetary cage, disposed within the actuator shell;  
4 a prime mover having a first prime mover portion rigidly  
5 fixed to the actuator shell and a second prime mover portion,  
6 adjacent to, and movable with respect to, the first prime mover  
7 portion, rigidly fixed to the planetary gear cage, and capable  
8 of exerting a torque on the first prime mover portion;  
9 a cross-roller bearing having a first bearing portion  
10 rigidly fixed to the actuator shell and a second bearing  
11 portion, movable with respect to the first bearing portion;  
12 an output attachment plate rigidly fixed to the second  
13 bearing portion;  
14 a shell gear rigidly fixed to the actuator shell;  
15 an output gear rigidly fixed to the output attachment  
16 plate; and  
17 one or more planetary gears, disposed in the planetary  
18 cage, each having a first gear portion meshed to the shell gear  
19 and a second gear portion, adjacent to the first gear portion,  
20 meshed to the output gear.

1 2. The rotary actuator of claim 1 further comprising a first  
2 structural link rigidly connected to the actuator shell and a  
3 second structural link rigidly connected to the output  
4 attachment plate.

1 3. The rotary actuator of claim 2 wherein the first link and  
2 second links are attached to the actuator shell and output  
3 attachment plate, respectively, by quick-change attachment  
4 structures.

1 4. The rotary actuator of claim 3 wherein each of the quick-  
2 change attachment structures comprises a first radial groove in  
3 the structural link, a second radial groove, adjacent to the  
4 first radial groove, in the mating portion of the rotary  
5 actuator, and a radial clamp, extending about the circumference  
6 of the first and second radial grooves.

1 5. The rotary actuator of claim 2 wherein the first structural  
2 link is attached to the actuator shell immediately adjacent to  
3 the cross-roller bearing and the second structural link is  
4 attached to the output attachment plate immediately adjacent to  
5 the cross-roller bearing.

1 6. A rotary actuator comprising:  
2 an actuator shell;  
3 an eccentric cage, disposed within the actuator shell;  
4 a prime mover having a first prime mover portion rigidly  
5 fixed to the actuator shell and a second prime mover portion,  
6 rotatable with respect to the first prime mover portion, rigidly  
7 fixed to the eccentric cage, and capable of exerting a torque on  
8 the first prime mover portion;  
9 a cross-roller bearing having a first bearing portion  
10 rigidly fixed to the actuator shell and a second bearing  
11 portion, free in rotation with respect to the first bearing  
12 portion;  
13 an output attachment plate rigidly fixed to the second  
14 bearing portion;  
15 a shell gear rigidly fixed to the actuator shell;  
16 an output gear rigidly fixed to the output attachment  
17 plate; and  
18 an eccentric, disposed about the eccentric cage, having a  
19 first gear portion meshed to the shell gear and a second gear

20 portion, adjacent to the first gear portion, meshed to the  
21 output gear.

1 7. The rotary actuator of claim 6 further comprising a first  
2 structural link rigidly connected to the actuator shell and a  
3 second structural link rigidly connected to the output  
4 attachment plate.

1 8. The rotary actuator of claim 7 wherein the first link and  
2 second links are attached to the actuator shell and output  
3 attachment plate, respectively, by quick-change attachment  
4 structures.

1 9. The rotary actuator of claim 8 wherein each of the quick-  
2 change attachment structures comprises a first radial groove in  
3 the structural link, a second radial groove, adjacent to the  
4 first radial groove, in the mating portion of the rotary  
5 actuator, and a radial clamp, extending about the circumference  
6 of the first and second radial grooves.

1 10. The rotary actuator of claim 7 wherein the first structural  
2 link is attached to the actuator shell immediately adjacent to  
3 the cross-roller bearing and the second structural link is  
4 attached to the output attachment plate immediately adjacent to  
5 the cross-roller bearing.

1 11. The rotary actuator of claim 6 wherein one or more of the  
2 first and second gear portions employs gear teeth having a  
3 circular profile.

1 12. The rotary actuator of claim 11 wherein the gear teeth  
2 having a circular profile are dimensioned to have a slight  
3 interference.

1 13. The rotary actuator of claim 12 wherein one or more of the  
2 gear teeth having a circular profile have a cavity disposed  
3 therein in order to reduce the stiffness of the gear teeth.

1 14. The rotary actuator of claim 6 wherein 10 or more gear  
2 teeth within one or more of the first and second gear portions  
3 are in contact at any point in time.

1 15. A rotary actuator comprising:

2 an actuator shell;

3 a first planetary cage, disposed within the actuator shell;

4 a prime mover having a first prime mover portion rigidly  
5 fixed to the actuator shell and a second prime mover portion,  
6 rotatable with respect to the first prime mover portion, rigidly  
7 fixed to the first planetary gear cage, and capable of exerting  
8 a torque on the first prime mover portion;

9 a shaft, having a shaft gear rigidly fixed thereto;

10 a second planetary gear cage, rotatable with respect to the  
11 first planetary gear cage and the shaft, having a cage gear  
12 rigidly fixed thereto;

13 one or more first stage planetary gears disposed in the  
14 first planetary gear cage, each having a first gear portion  
15 meshed to the shaft gear and a second gear portion, adjacent to  
16 the first gear portion, meshed to the cage gear;

17 a cross-roller bearing having a first bearing portion  
18 rigidly fixed to the actuator shell and a second bearing  
19 portion, free in rotation with respect to the first bearing  
20 portion;

21 an output attachment plate rigidly fixed to the second  
22 bearing portion;

23 a shell gear rigidly fixed to the actuator shell;

24 an output gear rigidly fixed to the output attachment  
25 plate; and

26 one or more second stage planetary gears disposed in the  
27 second planetary gear cage, each having a first gear portion  
28 meshed to the shell gear and a second gear portion, adjacent to  
29 the first gear portion, meshed to the output gear.

1 16. The rotary actuator of claim 15 further comprising a first  
2 structural link rigidly connected to the actuator shell and a  
3 second structural link rigidly connected to the output  
4 attachment plate.

1 17. The rotary actuator of claim 16 wherein the first link and  
2 second links are attached to the actuator shell and output  
3 attachment plate, respectively, by quick-change attachment  
4 structures.

1 18. The rotary actuator of claim 17 wherein each of the quick-  
2 change attachment structures comprises a first radial groove in  
3 the structural link, a second radial groove, adjacent to the  
4 first radial groove, in the mating portion of the rotary  
5 actuator, and a radial clamp, extending about the circumference  
6 of the first and second radial grooves.

1 19. The rotary actuator of claim 16 wherein the first  
2 structural link is attached to the actuator shell immediately  
3 adjacent to the cross-roller bearing and the second structural  
4 link is attached to the output attachment plate immediately  
5 adjacent to the cross-roller bearing.

1 20. The rotary actuator of claim 15 wherein one or more of the  
2 first and second gear portions employs gear teeth having a  
3 circular profile.

1 21. The rotary actuator of claim 20 wherein the gear teeth  
2 having a circular profile are dimensioned to have a slight  
3 interference.

1 22. The rotary actuator of claim 21 wherein one or more of the  
2 gear teeth having a circular profile have a cavity disposed  
3 therein in order to reduce the stiffness of the gear teeth.

1 23. The rotary actuator of claim 15 wherein 10 or more gear  
2 teeth within one or more of the first and second gear portions  
3 are in contact at any point in time.